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Art. IX.—*The Building Stones of Victoria, Part II. The Igneous Rocks.*

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(With Plate XVI.)

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Introduction.

In the following paper some Victorian igneous rocks used as building stones are described. Of the fourteen rocks included here, twelve have been used for constructional or ornamental purposes as well as in monumental masons' work, and one in monumental work alone, and one, the Tynong granite, has recently been selected for use in the Victorian Shrine of Remembrance.

H. C. Richards (13) in 1909 published a description of eight Victorian sandstones used as building stones. The title of his paper was "The Building Stones of Victoria—Part I.: The Sandstones." Therefore, this paper is styled "The Building Stones of Victoria, Part II.: The Igneous Rocks."

In addition to the building stones described here, there are other igneous rocks occurring in Victoria which have been used in the past for building stones, and of course many others which may be used in the future, but so far as the writer is aware those referred to here include most of those being quarried at the present time for purposes of building.

From Victorian igneous rocks entire buildings have been erected, or they have served as basecourses, as ornamental pillars or columns, and for monumental works, and at the present time thin slabs are frequently cut for use as a veneer on concrete buildings.

Igneous rocks used as building stones are divided into three classes by stonemasons. The first is that of the "granites," which in this connection includes all coarse, even-grained types of igneous rocks, and these are usually capable of taking a polish. The second is the "porphyry" class, including all rocks with large porphyritic felspar crystals. As a rule, these are used in small polished slabs for ornamental purposes. The "bluestones" or basalts form the third class. These are sombre, blue-grey coloured fine-grained rocks, whose chief use as building stones is for basecourses, where their dark colour makes an effective contrast with a lighter coloured main structure.

The following scheme has been adopted in the description of each building stone. In an introductory paragraph the site of the quarry, the amount of stone available there, and the systems of jointing with their corollary, the size of blocks obtainable, are described. In a paragraph headed "Appearance," the colour and structure of the stone are referred to as well as any blemishes it may possess. Under "Working Qualities," the ease of sawing and polishing the stone and the quality of its polish are treated. Following this, all the tests done on each stone are grouped together, and in a final paragraph a tabulation of some of the buildings erected of the stone is given, with a summary of the principal characters which either recommend or forbid its use.

The rocks are described in the order of the classes recognised by technical workers in the trade. Within each class, where there is more than one representative, that stone most in use for building is treated first, and is followed by the rocks in descending order of their use up to the present time.

Of the quarries described here all have been visited by the writer, with the exception of those at Gabo Island and Tallangatta. All crushing strength tests except that of the Gabo Island granite have been carried out in the Melbourne University Engineering School, on test pieces, most of which have been prepared by the writer. The remaining tests have been done by the writer unless the contrary is stated.

The writer desires to acknowledge gratefully the helpful advice and criticism offered to her throughout this work by Professor Skeats, and to thank Associate-Professor Summers also for his continuous assistance.

Messrs. William Train and Co., and the owners and managers of the various quarries visited, have been always most courteous in throwing open their works for inspection, and in giving much practical advice.

Previous Literature.

In 1860 a committee of the Royal Society of Victoria published a report of building materials (1) occurring in Victoria. The report which, so far as is known, is the first record in print of such occurrences, describes rather fully the basalt or "bluestone" of the colony, without, however, specifying localities from which it was then obtained. It records various quarries for granite, indicating that stone for building in Melbourne had been obtained at that period from Gellibrand's Hill, at Broadmeadows, and from Gabo Island.

In 1864 a treatise on "Australian Building Stones," by J. G. Knight (2), was published in London. As the author was the chairman of the Committee of the Royal Society referred to above, this treatise contains in a fuller form practically the same information given in the Committee's Report.

Later reports are confined to lists of localities of quarries in granite, greenstone, basalt, serpentine, etc., until in 1915 R. T. Baker published the "Building and Ornamental Stones of Australia" (17), which includes notes on many of the igneous rocks of Victoria, referring to their use or possible use as building stones. A similar list, though a shorter one, appears in the Commonwealth Year Book for 1909 (18). Until the present time the only other references have been reports in Geological Survey Records on single quarries and a few references in reports on the building stones of other States.

Publications dealing with the use or possibilities of Victorian igneous rocks as building stones as well as other books and papers referred to here are listed in the bibliography at the end of the paper.

The Igneous Building Stones of Victoria.

Granites.

The "granite" of the worker in the stone trade has been defined above as a coarse, even-grained type of igneous rock which can usually be polished. This group of rocks is subdivided according to the predominating colour of each type into red or pink, grey, green and black granites. In a red or pink granite the felspar present is usually orthoclase or an alkali plagioclase which has become reddish brown by iron staining. This felspar being present in comparatively large proportion, imparts its reddish brown colour to the whole rock. These "red or pink granites" conform most nearly to the granite of the petrologist. In a grey granite the felspar present is a white one uncoloured by iron, which occurs with small amounts of black mica, giving a "pepper and salt" or grey colour to the stone. The petrologist's granodiorite is included here. The green granites derive their colour from the minerals hornblende and epidote. The latter of these occurs as an alteration production of plagioclase felspar. Such rocks are diorites. A black "granite" may be composed of orthoclase or plagioclase felspar, augite and biotite, with an iron oxide, when it will fall into either the syenite or diorite petrological class. With the addition of olivine and the subtraction of some of the felspar, the rock becomes a gabbro. The combined effect of these minerals approximates to a black stone. The first two classes include a far greater proportion of rocks than do the last two.

In addition to this subdivision by colour, granites are classified according to their grain size. A convenient method of classification is outlined by T. Nelson Dale (10). By it a granite containing felspars of more than 1 centimetre (2/5 inch) diameter is classed as coarse-grained, one with felspar whose diameters lie between 0·5 cm. (1/5 inch) and 1 cm. (2/5 inch), is medium grained, and all those with felspars below 0·5 cm. are fine-grained. Throughout this paper this scale is referred to when the terms coarse-grained, medium-grained, and fine-grained are used. The lower limit for the coarse-grained division seems rather a high one, but since this is the most distinctly enunciated scale of grain size, and is quoted by J. Allen Howe in the "Geology of Building Stones" (15), it has been adopted here.

In the quarrying of granite the system of joints which occur in the rock are important. In most granite quarries it is found that the rock will split most easily in one definite direction, which is known always as the "rift." In a direction at right angles to the rift a granite will also split with ease, but slightly less well than along the rift. This second direction of splitting is known as the "grain." The terms "rift" and "grain" are used throughout this paper with the same significance. In most quarries the rift and grain are vertical, and the joint system in the third dimension is usually horizontal, so that a sheet-like structure in the granite is suggested. This third joint is never so perfect as either rift or grain, the break being usually concave or convex, and the "sheets" more or less lens-shaped.

Another term of almost universal application in quarries, which needs explanation, is the word "dry." A "dry" is a direction in a rock mass along which a block of the stone tends to fracture, but may not do so until after it has been quarried and exposed for some time. The fracture does not usually take place along a plane, but along a curved direction and penetrates for but a short distance into a block. "Drys" are spaced quite irregularly, and their existence in a block of stone is often not suspected until after cutting and dressing is completed, when if a "dry" shows up the block must be rejected.

Harcourt Granite.

The granite used most widely in Victoria as a building stone outcrops over an area of some 150 square miles in the neighbourhood of Harcourt and Ravenswood, 80 miles north of Melbourne and 20 miles south of Bendigo. It is quarried on the side of Mount Alexander, three miles east of the Harcourt railway station, on the Melbourne to Bendigo line, where quarrying commenced over sixty years ago, and during this period a large quantity of stone has been removed.

The joint system in this rock mass is exceedingly favourable for the extraction of large blocks. The "rift" or easiest direction of splitting the stone runs vertically north and south, and the "grain" is also vertical, and runs east and west. Rift and grain are so spaced that very large blocks can be obtained; in 1921 a block 84 feet long, 28 feet wide and 25 feet deep, which weighed 5000 tons was moved by a single charge of powder.

Appearance.—This granite is a light grey one, containing large crystals of white felspar and glassy quartz, and a smaller quantity of biotite mica. The felspars average 1/5 inch in diameter, so that the granite just falls within the medium-grained division of the Nelson Dale scale. The grain size is very even through the rock except where "black spots" or "heathen" occur. These are patches of dark fine-grained material averaging two square inches in size, although much larger ones occur. They are rich in the mineral biotite, and form basic segregations. They show prominently on sawn and polished blocks and occur at an average distance apart of two feet. Less frequently small acid veins about half an inch wide occur, which contain quartz and felspar alone. These are not very noticeable on account of the prevailing light grey colour of this stone. Its light grey colour is this granite's most noticeable feature, and is especially marked on smooth, unpolished blocks. The polished stone has a darker colour, which becomes somewhat lighter after exposure, apparently on account of the gradual evaporation of quarry damp. The granite placed in 1926 in the additions to the State Savings Bank in Elizabeth Street was distinctly darker at first than that in the first part of the building erected in 1911, but now the junction between the two cannot be distinguished. Specimens from all parts of the quarry are very similar, and it is noticeable that the rock outcropping at Big Hill, ten miles to the north of this quarry, does not differ in grain size nor mineral composition.

Working Qualities.—Rift and grain in this granite are so well developed as to make the ease of working this stone at the quarry a standard of excellence among granite masons. Blocks of all sizes and shapes required are obtainable, and since the supply is practically inexhaustible any type of work can be undertaken in this stone. At the mason's yard this stone takes a good edge or "arris," and it polishes well, although biotite is inclined to flake off from the surface, leaving it uneven.

Resistance to Crushing.—This stone has been tested in the Melbourne University Engineering School three times for its resistance to a crushing stress. Three inch cubes were used for the tests, which were conducted on the dry stone. The cubes crushed at 11,444 lbs. per sq. in. (736 tons per sq. ft.), 11,333 lbs. per sq. in. (728 tons per sq. ft.), and 8510 lbs. per sq. in. (547 tons per sq. ft.) respectively. The stone has a somewhat lower crushing strength than most of the granites described here.

Absorption.—The percentage of water absorbed was determined by immersing a small weighed and dried block of the stone in water. The rectangular shape of the block made the conditions approximate to those experienced by the stone in a building in wet weather. After four days' immersion the block absorbed 0·11% of its weight of water, so that Harcourt granite may be called impervious for all practical purposes.

Chemical Analysis.—A chemical analysis of this rock has been made by Mr. G. Ampt, and the result published in a paper by Dr. H. S. Summers (16). It is included here under Chemical Analyses at the end of the paper.

Specific Gravity and Weight per cubic foot.—The specific gravity of this granite is 2·678, and hence the weight of a cubic foot is 167·5 lbs., which is a normal weight for a granitic rock.

Microscopic Examination.—A thin section of this rock shows idiomorphic crystals of felspars, interstitial quartz, in some cases under strain, and highly pleochroic biotite. There are a few occurrences of the accessory minerals apatite, zircon and magnetite. The relative grain size has been calculated for the three principal constituents by an adaptation of Rosiwal's method for measuring the dimensions of minerals (7). This rock is coarse-grained enough for the measurements to be made in millimetres on the polished surface of the rock itself. The result of twelve traverses gave the ratio Quartz: Felspar: Biotite, as 4 : 5 : 2.

Felspar is in the form of plagioclase and orthoclase in the proportion of 3 : 2. The plagioclase was determined as Ab_1An_1, or $Na_2O\ CaO\ 2Al_2O_3.8SiO_2$ by measurement of its angle of extinction. Orthoclase has altered to kaolin, which has become iron-stained, and some of the plagioclase has changed to epidote. This rock belongs to the adamellite class, since more than one-third and less than two-thirds of the felspar is orthoclase. In the American Classification the rock falls into Class 1, Persalane; Order 4, Brittanare; Rang 2, Toscanase; Subrang 3, Toscanose.

A portion of a basic segregation was examined under the microscope. It is distinctly fine-grained. Plagioclase is more abundant than orthoclase and the former shows marked alteration to epidote. The section is crowded with small, stumpy biotite crystals in greater abundance than in the normal rock. Quartz is also present. This section was difficult to obtain since the basic segregations are crumbly.

Uses.—This granite is widely used in Melbourne. Some of the better known buildings in which it appears are the Colonial Mutual Life Assurance, formerly the Equitable Life Assurance, where the upper storeys have been constructed of smooth, unpolished blocks, the Commercial Travellers' Club, the State Savings Bank, the Herald Newspaper Office, the Union Bank, the Flinders Street Railway Station, and many others. The stone is seen throughout the city in polished ornamental panels, pillars, steps and basecourses.

Its very light grey colour must be regarded as a defect in this stone, because it becomes dirty rapidly in a city atmosphere. The gateway of the Fish Market in Flinders Street, and Rocke, Tompsitt's warehouse in the same street are examples of dirty Harcourt stone.

The dark basic segregations or "heathen" are a disfigurement. These may be seen in the wall of the head office of the State Savings Bank.

No other granite, either Victorian or imported, has been used to the same extent as this stone for building, ornamental and monumental purposes in Melbourne.

Wangaratta Granite.

Granite from this district has been used locally and in Melbourne. It is quarried in the Warby Ranges, about seven miles SW. of Wangaratta. The Warby Ranges consist of a granite inlier rising abruptly from a plain composed of Recent material.

The quarry for building stone has been made in an area where segregation of pyrites has occurred in the granite, giving it an appearance distinctly different from that of the pyrites-free granite found at no great distance. The quarry is on a hillside, and after the blocks are dislodged and shaped into roughly rectangular blocks they are rolled downhill and levered on to lorries. The working face slopes nearly parallel with the slope of the hillside. This quarry face is very uneven, since there is trace neither of rift nor of grain in the granite, but "drys," whose nature is defined above, are found irregularly through the stone. On account of the "drys," the size of the blocks obtainable is very uncertain, and a great deal of material has to be rejected. Blocks up to six feet in length have been got out, but there is no guarantee that blocks of this size can be secured frequently. The size more usually obtained is 2 ft. 6 in. long by 1 ft. square. This lack of regular jointing somewhat restricts the use of this granite as a building stone.

Appearance.—The granite is pink and even-grained, but its appearance varies with the amount of pyrites present, and the proportion of this mineral which has been oxidised. Three distinct types can be recognised, and are described here as A, B and C.

Type A is a pale pink, fine-grained granitic rock, containing abundant creamy felspar, averaging 1/20 inch in diameter, grains of quartz, and scattered pyrite cubes. Some of these have been lost, leaving small cavities in the rock.

Type B is a very soft friable cream-coloured rock. It contains felspar, kaolin, quartz, but no pyrites, and is very porous.

Type C is a dark, fine-grained stone, of a colour ranging from pale pink to purple. Felspar is very abundant, and there is a good deal of quartz. Pyrites is absent, though occasionally cubic cavities, which contained originally pyrites crystals, are to be seen.

Limonite resulting from the oxidation of the sulphide mineral has penetrated the felspar, colouring it dark pink and purple, and probably causing the greater hardness of this type. Type C has a warm and attractive appearance on either smooth or rock-faced surfaces due to the alternating red and cream patches, according to the varying richness of the stone in ferric oxide.

Working Qualities.—The buildings in which this stone has been used have been constructed of comparatively small blocks, averaging 2 feet 6 inches by 1 foot square. Types A, B and C have been used for slightly different purposes in building construction. Type A, rich in unaltered pyrites, is used with a rock-faced finish in the construction of walls. Men who have worked on both say that this stone may be worked with about the same ease as Melbourne basalt. When it is being chiselled a strong smell of sulphur dioxide is noticed. It will not work up to a particularly sharp arris. Type B being a soft stone is very easy to work, and is used with the axed finish required in window surrounds. Type C, the hardest stone, is selected for rock-faced work, and is used chiefly in walls and foundations.

The rock rich in pyrites (type A) was found to take a good polish; square cross-sections of pyrites, prismatic crystals of cream felspar and quartz grains showing up well against a pale pink groundmass. The only undesirable feature is the presence of some small pits on the surface. Type C, which is coloured purple-red, is much too porous to look well when polished, though the solid parts take a high polish. Holes 1/8th in. in diameter and 1/16th in. deep are commonly seen.

Resistance to Crushing.—Specimens of types A, B and C were tested for their resistance to crushing. Type A, which is the stone containing unaltered pyrites crystals, is much the strongest of the three, since it broke only under a load of 19,600 lbs. per sq. in. (1261 tons per sq. ft.). Type B, the soft stone, fractured under a load of 7,110 lbs. per sq. in. (457 tons per sq. ft.), which is a low value for the crushing strength of any igneous rock. Type C proved rather stronger, breaking beneath a load of 9,670 lbs. per sq. in. (622 tons per sq. ft.). The comparative weakness under a crushing load of the two latter stones compared with normal igneous rocks can be attributed to the changes suffered by the stone in the oxidation of its pyrites. The figures indicate, however, that even these two stones are quite strong enough for use for ordinary purposes in a building.

Absorption Percentage.—Rectangular blocks of all the stones were tested for their absorption percentages. They were immersed in distilled water until they ceased to gain in weight, when they were judged to be completely saturated. This took a different period for each stone. All their absorption percentages are above the average of normal granitic types, due to the cavities left, when pyrites cubes are lost, and the general alteration suffered by the stones.

Type A	immersed for	9	days	gained	1·45%	of its weight.
,, B	,, ,,	13	,,	,,	3·75%	,, ,,
,, C	,, ,,	14	,,	,,	4·08%	,, ,,

Specific Gravity and Weight per Cubic Foot.—Type A has a specific gravity of 2·512, and weighs 157 lbs. per cubic foot. Type B weighs 145 lbs. per cubic foot and its specific gravity is 2·324. The specific gravity of type C is 2·446, and its weight per cubic foot is 152·5 lbs.

These figures are all low, which is probably due to the fact that the stones are rather porous. The resulting low weight per cubic foot is a factor in favour of the use of this stone.

Microscopic Examination.—In a thin section of type A, felspar makes up two-thirds of the rock, quartz bulks largely, and there are some cubic crystals of pyrites. The felspar is allotriomorphic, much of it being clouded by formation of kaolin, which is stained by ferric oxide. Epidote and sericite have formed also, and some of the unaltered felspar shows lamellar twinning. Kaolin is formed typically from alkalic felspar, while sericite and epidote come from calcic plagioclase, and since a greater proportion of the felspar present has altered to ironstained kaolin than to epidote and sericite, this rock may be termed an altered granite.

Type B is very similar to type A, except that fresh, unaltered pyrites cubes are absent from B. Clouded felspar is the most abundant mineral. Kaolinization and limonitic staining are marked, and the development of sericite from plagioclase is more noticeable than in type A.

A thin section of type C is distinguished from types A and B by the greater abundance of hematite present. After its formation by oxidation from pyrites, the hematite penetrated along cleavage cracks of the kaolinized felspar, making a rectangular network within the mineral (Pl. XVI., Fig. 1), which has strengthened and hardened the stone. Little quartz is present, and no unaltered pyrites.

Uses.—The stone has been used in two churches in Wangaratta. The first part of the Anglican Cathedral was built about 1908 of stone from this quarry, and in 1922 the quarry was reopened to obtain stone for additions to this building. Blocks of the hard red material (type C) are used with a rock-faced finish in the main structure, while the softer type B is used for the window surrounds. Rock was extracted from this quarry 60 years ago, when blocks for the Catholic Church in Wangaratta were obtained. In Melbourne sawn blocks of Wangaratta granite have been used in Collins House, Collins Street. The stone used appears most like type C. For the keystone of the arch over the entrance a block of Sydney sandstone was introduced.

The blocks are light reddish in colour, and show patches of a darker colour due to the oxidation and leaching of iron of the pyrites crystals originally contained in the rock. Such differential staining is more usually associated with sedimentary rocks, and the rock in this building is often mistaken for such.

The warm reddish colour of this stone is very attractive, and should make it a popular one for city use, since it discolours less readily after exposure to a city atmosphere than do stones of paler tints.

Cape Woolamai Granite.

The granite outcrop of Cape Woolamai forms the south-eastern point of Phillip Island in Westernport Bay, and has provided stone for building in Melbourne. Cape Woolamai is two miles across Newhaven Strait from San Remo, a township on the mainland 80 miles by road and rail south-west of Melbourne. By another route the granite may be taken about 15 miles by water to Stony Point, which is 46 miles from the city by rail. The distance from Cape Woolamai to Melbourne directly by water is approximately 65 miles. The depth of water at the stone landing stage at the Cape is 2 fathoms. Three hundred yards out it has increased to 12 fathoms.

The Cape is formed of a granite cliff, rising out of the sea to a height of about 300 feet. At its widest, the Cape is one mile across, and the granite is nowhere covered by more than a few inches of unconsolidated sands. From the headland a jetty of granite blocks was built out into Westernport, from which boats removed the stone. At present the main quarry, which is connected to this jetty by a tramline somewhat out of repair, is under water at high tide. The perpendicular sides of this disused quarry show that large well-shaped blocks were obtained by fracture along regular joint planes, one of which strikes north and south with the face of the joint plane dipping 60° to the east, while the second strikes east and west and dips 30° south. Blocks up to 6 ft. in length by 2 ft. square are still lying at the stone landing stage, while pillars 12 ft. high by 2 ft. square, and blocks 7 ft. long by 3 ft. 6 in. wide by 2 ft. 6 in. high, were used in the base-courses and portico of the Equitable Building, now the Colonial Mutual Life Assurance Building.

The granite mass contains cream-coloured acid veins and vughs of large pink felspar crystals, which mar the evenness of grain of the rock. Segregations of basic material do not commonly occur in this stone, which is remarkably free from any dark mineral.

Appearance.—This granite has a pleasant colour varying between a light and a dark pink, according to the amount of alteration suffered by the felspar present. The felspar crystals average three-tenths of an inch in diameter, so that the grain size of the rock is medium. It is composed mainly of pink felspar and quartz. In addition a little green-stained felspar and a subordinate amount of black mica are present.

The granite when polished has a darker colour, and makes a handsome ornamental stone. Narrow veins about 2 inches wide, containing large quartz and felspar crystals from 1 inch to 2 inches in length, cut across blocks of the normal coarse-grained granite. More rarely portions of the stone are marred by dark streaks caused by the segregation of ferromagnesian minerals in narrow veins. Some of these can be seen in the base-course of the Equitable Building. One vein measures 18 inches long and 2 inches wide. These veins are not so dark-coloured as the "black spots" in Harcourt granite, because the black minerals are not so closely packed, and therefore are less of a disfigurement to the stone.

Working Qualities.—Little is known of other working qualities than the polish of this stone, because it is over 30 years since it was worked. On a test piece in the laboratory a surface was smoothed and an extremely fine polish was obtained with relatively little work.

Resistance to Crushing.—This granite has a remarkably high crushing strength for a rock of this grain size. A block measuring approximately 1½ sq. in. by 2 in. broke under a load of 27,100 lbs. per sq. in. (1743 tons per sq. ft.).

Absorption Percentage.—A smooth block of this granite was immersed in distilled water for 12 days, during which time it absorbed only 0·18% of its weight of water.

Chemical Analysis.—The result of a chemical analysis of this rock, which has been carried out by Mr. A. G. Hall for Dr. H. S. Summers (16), appears at the end of this paper. This granite is the richest in silica of the eight granites and granodiorites, whose analyses are published in the paper cited.

Specific Gravity and Weight per Cubic Foot.—The weight per cubic foot of this stone is 165 lbs., calculated from the specific gravity of 2·643, given with the chemical analysis (16).

Microscopic Examination.—The minerals present are felspar, quartz, biotite, apatite and zircon. Felspar is in the form of microperthite altered to kaolin, and of plagioclase near oligoclase. Some microperthite crystals show a thin film of iron oxide, which is the cause of the reddish tint seen in most of the felspar in hand-specimens. The tinge of green seen in others is due to small crystals of epidote, formed from plagioclase. Large grains of quartz are abundant, while flakes of biotite in a dark-coloured, corroded form are rare. Some of these are altered to chlorite. Apatite and zircon are included in mica. The proportion of orthoclase to plagioclase is greater than 2 to 1; therefore this rock is a true granite.

Uses.—Large polished blocks (7 ft. long by 3 ft. 6 in. wide by 2 ft. 6 in. high) form the base-course of the Colonial Mutual Life Building, and pillars 12 ft. high flank the entrance. This was built for the Equitable Life Assurance Company in 1893, and the Cape Woolamai quarry was opened to supply stone for this building. So far as is known, it is used nowhere else in the city. Vertical cracks have developed across the face of some blocks. It is likely that these have arisen from "drys" in the granite, while the appearance of some blocks is marred by quartz veins. It is reported that specks of gold can be seen on some of the polished blocks.

The size of blocks obtainable, the excellent polish and colour of this granite are in its favour, and though the quarry is rather inaccessible, its position at the water's edge makes possible direct water transport to the city by boats of shallow draught.

Gabo Island Granite.

This small island is composed of granite, which has been quarried and used for building. It is close to the coast near the boundary between Victoria and New South Wales, and lies near the sea route between Sydney and Melbourne, 242 miles from the former and 333 from the latter. It is thus accessible by boat from either capital. Admiralty charts record the depth at the jetty as 5 fathoms. Blocks measuring 2 feet high by 3 feet square are in use.

Appearance.—The presence of abundant red felspar gives an attractive pink colour to this rock. It is composed of comparatively small crystals, all uniform in size. Since the felspars have an average length of one-tenth of an inch, the rock falls into the fine-grained group of building stones. In a polished block the colour is dark pink, though rectangular pale green felspars frequently occur. The dark red colour of rock-faced blocks of this stone can be seen in the Elizabeth Street Post Office, Melbourne. A vein, half an inch wide, of very fine grained quartz and pink felspar crosses one of the hand-specimens examined.

Working Qualities.—Blocks of this stone have been left exposed for 60 years in a stonemason's yard in Melbourne. They have retained a good " arris " and polish until the present time.

The granite polishes fairly well, although small pits are left on the surface where hornblende has been torn out while the stone was being ground smooth.

Resistance to Crushing.—The result of crushing strength tests on this granite is published by Baker and Nangle (12). Three 3-inch cubes were tested and their strengths in lbs. per sq. in. were 15,200, 14,900, and 17,500 respectively (979, 950, and 1128 tons per sq. ft.).

Absorption Percentage.—A small block of the stone dressed to a rectangular shape was immersed in distilled water for eight days, when it was found to have increased in weight by 0·39%.

Chemical Analysis.—The chemical analysis is recorded at the end of the paper.

Specific Gravity and Weight per Cubic Foot.—The weight per cubic foot of this granite is slightly under 165 lbs., calculated from the specific gravity (16), which is 2·635.

Fire Test.—Baker and Nangle (12) have carried out tests to discover the effect of heating and sudden cooling by streams of water on Gabo Island granite. These tests imitate the effect of fire and fire-fighting apparatus on a granite building. A cube was heated gradually to 783°C., and removed after 35 minutes, when it was found to be badly cracked. A second cube was heated gradually to 544°C. and plunged suddenly into cold water. This cube was almost unaffected.

Microscopic Examination.—This granite contains altered felspar, abundant quartz and altered hornblende. Most of the felspar is in the form of a microperthitic intergrowth beneath a film of iron-stained kaolin, while some of it shows lamellar twinning and a cloud of alteration products (epidote, sericite, etc.), in which are caught up many small flakes of chlorite, which is the cause of the green felspar noticed in the hand specimen. Ilmenite and apatite also occur. The rock is best described as a normal granite.

Uses.—Polished columns of this granite are used in the building of the Australian Travel Service, 493 Collins Street, rock-faced blocks of the stone support Tasmanian sandstone columns in the Elizabeth Street Post Office, and smooth-dressed blocks form the base-course of the Customs House, Flinders Street.

The colour of this stone readily recommends its use, and its strength is great enough to fulfil any requirement. Unfortunately, the long distance of Gabo Island from a city will operate against the frequent use of the granite from there.

Orbost Granite.

About two miles east of Orbost, on the road to Mallacoota Inlet, and 233 miles east of Melbourne, Young's Creek has exposed a large face of granite which was quarried for use in the Commonwealth Bank in Melbourne in 1923. No soil overburden covers the granite, and there is an exposure about 40 feet high by 60 feet in width. The face of stone in the quarry is remarkably irregular, and shows more or less conchoidal breaks, which prove that there is no continuity in the jointing system in the stone. The most marked joint runs on a sloping plane at right angles to the face of the quarry, but is not continuous for any distance.

Appearance.—This is a greenish-grey granite, considerably darker in colour than the Harcourt stone. Its green tint comes from stained felspar, and is an attractive colour, especially when seen on a polished block. The felspars average one-tenth of an inch in diameter, and the granite is therefore fine-grained.

The granite mass is traversed by many veins of quartz up to an inch in width, with some of which epidote and carbonate minerals are associated. Large, dark-coloured segregations of basic minerals, and narrow veins of dark-coloured minerals, also mar the appearance of the stone, and in addition blocks up to 12 inches square of fine-grained sedimentary material occur as inclusions. Some of these are surrounded by a rim of partially absorbed material. Even small hand specimens cannot be obtained free from disfiguring "black spots." One block of stone outcropping near the quarry is traversed by three narrow dark veins, one of which on examination under the microscope was found to consist of a string of chlorite crystals altered from hornblende and biotite. The minerals from which the string of chlorite has been derived have resisted weathering to a greater degree than has the remainder of the rock, with the result that the narrow dark veins are the centres of three ridges standing about one inch above the general surface of the rock.

Working Qualities.—This stone was cut into two 2-inch cubical blocks for testing purposes, and it was noticeably easier to saw than most other granitic types, presumably on account of decomposition suffered by the minerals present. The stone polishes rather well, though the polished surface is somewhat pitted. These pits are due to the loss of biotite during the grinding of the rock.

Resistance to Crushing.—Two rectangular blocks each approximately a two inch cube of this granite were tested. One crushed beneath a load of 15,300 lbs. per sq. in. (984 tons per sq. ft.), while the other did not crush under the heaviest load of which the machine is capable, 100,000 lbs., or 25,400 lbs. per sq. in. (1633 tons per sq. ft.). It was noticed that although the specimen had not actually broken, it was just on the point of breaking. It should be pointed out that although the crushing strengths of these two cubes vary rather widely, they were prepared in a similar manner by the writer from a single block of the stone, and were crushed in the same machine by the same operator on the same day.

Absorption Percentage.—A smoothed block of Orbost granite absorbed 0·15% of its weight of distilled water after immersion for eight days.

Specific Gravity and Weight per Cubic Foot.—The specific gravity of this stone is 2·803, hence the weight per cubic foot is 175 lbs.

Microscopic Examination.—A thin section shows quartz in allotriomorphic and interstitial grains and felspar in relatively small idiomorphic crystals, which are altered considerably, though in a few crystals the lamellar twinning of the plagioclases can be detected. The plagioclase has been saussuritized, causing the formation of grains of zoisite, a little epidote and small, brightly polarizing fibres of mica, probably the soda mica, paragonite, since it has developed from plagioclase. Biotite is present, showing very extensive alteration to chlorite, which imparts a green tint to the rock, and a small proportion of hornblende also. Magnetite, apatite and zircon are accessories. The rock may be termed a granodiorite.

A thin section was cut of one of the foreign included blocks. This consists essentially of small angular interlocking quartz-grains set in a felspathic matrix. Flakes of chloritized biotite and cubes of pyrite occur sparingly. The inclusion is an indurated sandstone or quartzite. The junction between the inclusion and the normal granodiorite is marked by a band of quartz which has recrystallized and forms a polysynthetic mosaic.

Uses.—The sole use of this granite in Melbourne has been for the base-course of the Commonwealth Bank in Collins Street.

The stone is polished here, but the polish is not good. Most of the blocks are marred by black spots or inclusions of foreign rocks.

This rock is found at such a great distance from Melbourne, and is so variable in appearance, that it will probably never be widely used. The heart of the stone would almost certainly be more uniform in appearance. The colour is distinctly attractive, and in comparison with other granites this one is more easily worked.

Trawool Granite.

Granite from this locality was quarried for building about 30 years ago. The Monthly Progress Report of the Geological Survey for 1899 (8) records the value of the granite obtained here in 1897 to be £2,100. The quarry site is 60 miles north of Melbourne, and within two miles south-west of the railway siding at Granite, on the Mansfield line. Quarrying was commenced on an outcrop beside the Trawool Creek, the water from which has now filled the quarry hole to within three or four feet of the top of its walls. The vertical walls of the quarry striking approximately north and south and east and west show that the joint system in the stone is good, which is further proved by a polished block measuring 4 ft. by 3 ft. 6 in. by 1 ft., lying near the quarry. This block was rejected because large felspar crystals 2 in. long by ½ in. wide have broken out of it, and cracks have developed in the stone.

The quarry was opened to supply stone for the Equitable Building, but early in the work it was abandoned on account of flaws such as those found in the rejected block described above. Machinery for all processes of dressing and polishing the stone was brought to the quarry. Gabo Island stone was also taken there to be dressed and polished.

Appearance.—It is a grey granite, containing white well-shaped felspar crystals in a finer-grained groundmass. The average grain-size of the felspar measured in a hand specimen is slightly over one-tenth of an inch, so that this granite is a fine-grained one. However, scattered through the rock are occasional large felspar crystals, over an inch in length, making the rock almost a porphyritic granite. These prominent felspar crystals make the stone more suitable for small pieces of ornamental work than for the construction of walls. The colour of the groundmass is darker than Harcourt stone, and consequently it does not change colour markedly after some years' exposure in city air.

Working Qualities.—On a polished surface of this stone numerous pittings occur which are due to the softness of the abundant biotite, which is torn out when the surface is being ground smooth. The stone therefore cannot be said to take a good polish. The tendency of large plagioclase phenocrysts to drop out during the working of the stone has already been noted.

Resistance to Crushing.—This has not been determined.

Absorption Percentage.—After immersion for twelve days a rectangular block of Trawool granite absorbed 0·28% of its weight of water.

Chemical Analysis and Specific Gravity.—The chemical analysis of the Trawool granite has been published (16), and the specific gravity determined as 2·666.

Weight per Cubic Foot.—The weight per cubic foot of this rock is 167 lbs.

Microscopic Examination. — Plagioclase near labradorite, quartz, perthite and biotite are found in the rock. Some of the biotite is chloritized and apatite and zircon are abundant accessory minerals. The rock is named adamellite by Dr. Summers (16). "Xenoliths" such as inclusions of micaceous hornfels and cordierite hornfels found in the Trawool stone show that the quarry is in an area close to the contact between sedimentary rock and adamellite (Tattam, 22).

Uses.—Polished blocks of this stone have been used in the base-courses of Sargood's and Griffiths' warehouses in Flinders Street, Melbourne, in pillars at 459 Little Collins Street, and in ornamental bands, and the steps of the Australian Mutual Provident Building, Collins Street.

Dromana Granite.

Granite outcrops in the hills behind Dromana township, 40 miles south of Melbourne, where a quarry has been made, which is distant about two and a half miles east of the Dromana jetty. The outcrop at this point is very extensive. Joints in the quarry, approximately east and west and north and south, are evenly spaced and are sufficiently far apart for the extraction of blocks 7 ft. long by 3 ft. square. In 1920 a private road was being made to the quarry, and in 1924 a report appeared in the press that a tramway was being constructed which would junction with the Melbourne road, not far from Red Hill station.

Appearance.—This is a green granite whose colour is derived from abundant felspar crystals altered to a bright apple-green. These felspars are rectangular, and stand out almost as phenocrysts from a finer-grained groundmass in which the felspar is creamy-yellow. Zoning in some of the green felspars can be detected by the unaided eye.

The average size of all the felspars is slightly less than one-twentieth of an inch, so that the Dromana stone ranks as a fine-grained building stone. Veins half an inch wide of honey-coloured quartz crystals cross some polished blocks of the stone. No basic segregations mar any specimens which have been examined, nor were they seen in the stone at the quarry on a visit in 1920.

Working Qualities.—The working qualities have been tested in Train's yard, South Melbourne, where large-sized slabs have been worked up. The granite is reported as comparing favourably with Harcourt granite for ease of working. It spalls off well, and works to a fine edge and polishes well and easily. It repays the work put into it better than does the Harcourt stone, since no unsightly dark patches appear upon the polished surface. The green tint is seen to better advantage on the polished stone.

Resistance to Crushing.—Two tests have been carried out on specimens of this stone obtained in 1918, when quarrying commenced first. Dry cubes measuring approximately two cubic inches were tested. The cubes crushed under loads of 17,870 and 16,300 lbs. per sq. in. respectively (1149 and 1048 tons per sq. ft.). The stone broke with the columnar fracture usual among granitic rocks. The values are high, and since the two tests gave results of approximately the same magnitude, it is safe to forecast for the stone obtained from Dromana strength sufficient for any purpose whatsoever.

Absorption Percentage.—The absorption percentage was determined on a small smooth rectangular block of the granite. After three days' immersion the block was found to have increased in weight by only 0·18%. Hence, like the Harcourt stone, it is nearly impervious to water.

Specific Gravity and Weight per Cubic Foot.—The specific gravity of this stone is 2·605; therefore, the weight per cubic foot is 163 lbs.

Microscopic Examination.—This examination shows a holocrystalline, even-grained rock which has undergone a good deal of alteration. The minerals present include felspar, quartz, hornblende, biotite and in very small quantity apatite, zircon, magnetite, pyrites and copper pyrites. Specks of gold are sometimes noticed on polished surfaces. The alteration of some of these minerals has given rise to others. Chlorite has resulted from changes in biotite and hornblende; kaolin and sericite from felspar, limonite from the iron-containing minerals. Orthoclase showing perthitic intergrowth with another alkali type, and a plagioclase, near labradorite, are both present. Minute flakes of chlorite occur throughout the felspar, which are no doubt responsible for its green colour. The proportion of orthoclase to plagioclase felspar being less than 1:2, this rock is classified as a granodiorite.

Uses.—This stone has been used in the steps of the entrance to and the facings for the block of shops in the Argus building, Elizabeth Street, and a Soldiers' Memorial in Daylesford contains a polished block of it.

It can be obtained in great quantity, the quarry is reasonably near Melbourne, the stone works up well, and has a handsome appearance from its bright green colour, which should give it special architectural value.

It is a stone that could be used on bigger pieces of work than has been the case in the past.

Colquhoun Granite.

Near the railway siding of Colquhoun, 28 miles east of Bairnsdale in Gippsland, and 195 miles east of Melbourne, a red granite has been quarried and worked up in Melbourne for monumental work. The quarry is one mile west of the Colquhoun railway siding and 200 yards south of the railway line. The country in this district is thickly timbered, and the side of a small gully has been chosen for the site of the quarry. There is no overburden on the patch of granite where quarrying was commenced, and though the rock mass appears lens-shaped and dips away from the surface to the north, the covering for some distance is thin, and is composed of unconsolidated sands whose removal should not represent a costly item in the quarrying operations.

A description of this quarry has been published by A. H. Sharpe (20).

The stone has been quarried over an area approximately 40 ft. long by 20 ft. wide and to a depth of 15 ft. Jointing is good in this stone. There are two systems of vertical joints which persist throughout the quarry. The " rift " trends north-north-east and the " grain " makes an angle of approximately 100° with the " rift." The joints are sufficiently far apart for the extraction of blocks of 4ft. 6 in. long by 2 ft. square. The granite exposed at the surface is somewhat iron-stained, but on a quarried surface is free from quartz veins and basic segregations.

Appearance.—This granite has a warm pink colour, and when polished is almost a brick-red. Its grain-size is fine, since its felspar crystals average slightly less than one-tenth of an inch in diameter. It contains beside felspar and quartz only a small amount of biotite mica. Blocks lying at the quarry have a margin of 6-9 inches wide of greyish-green granite, surrounding the normal red rock. Outside this rim again, is a brown, iron-stained band a quarter of an inch thick. A faint brown stain discolours the surface of some polished red blocks. It is only visible when the stone is polished. This rust mark is attributed to the passage of iron-bearing solutions carried upwards through the rock by evaporation. As described under the paragraph " Microscopic Examination." the origin of the rim of grey-green granite surrounding the red stone is ascribed to the same cause. All the stone worked up to the present has been taken from the surface or but slightly below it, and within a zone likely to be affected by evaporation. Neither the stain nor the greyish-green rim occurring along joints is likely to be found in blocks taken from greater depths.

Working Qualities.—This granite is reported to be difficult to work, but the stone takes and keeps a good arris. It takes an excellent and uniform polish, since it is composed almost entirely of quartz and felspar, which are of nearly equal hardness.

Resistance to Crushing.—The crushing strength of this granite, which was determined by a test on a two-inch cube, is 14,750 lbs. per sq. in. (946 tons per sq. ft).

Absorption Percentage.—This granite absorbed 0·32% of its weight of water after immersion for eight days.

Specific Gravity and Weight per Cubic Foot.—The specific gravity is 2·616 and the weight of a cubic foot of this granite is 163 lbs.

Microscopic Examination. — In thin section the following minerals are found, angular grains of quartz, orthoclase felspar showing perthitic intergrowth with an alkali plagioclase, subordinate plagioclase of composition between oligoclase and andesine, and grass-green and greenish-yellow biotite which occurs very sparingly. Much of the felspar is clouded by alteration to kaolin and epidote. The former is coloured brown by a thin film of iron oxide. The large proportion of orthoclase to plagioclase present in this rock places it among the true granites.

An examination of a thin section of the greenish-grey granite found as a rim 6-9 inches thick around the margin of some of the exposed blocks of the normal red stone shows perthitic felspar, plagioclase of composition near oligoclase, quartz, and a few flakes of chloritized biotite, some of which are green, while one or two whose ferrous iron has been oxidized show a brown staining. In the amount of iron-staining in the perthitic felspar lies the difference between this grey rock and the red granite which it surrounds. In the former, iron-staining is not so marked, and it is suggested that iron has been leached out from the originally stained felspar of the now grey rock, and carried to the surface of the block, or to a joint plane channel. A narrow, very much iron-stained rim, a quarter of an inch wide, was noted around the extreme edge of the block, while the grey rock, which may be regarded as a bleached type, lies immediately inside the narrow rim to a depth of about 9 inches, and inside it again is found the normal red rock unaffected by iron-bearing solutions rising to the surface by evaporation. The original red staining of the felspar is regarded as the work of magmatic vapours. Plagioclase has undergone alteration to epidote in both types and in both is subordinate to orthoclase in amount.

Uses.—A few monumental headstones have been worked up out of the red Colquhoun stone, but otherwise it has not been used. The rock has an attractive colour, a uniform texture, takes a good polish, and is easily accessible to a railway line. The difficulty of working it up and the distance of the quarry from Melbourne, while adding to the expense, should not prevent its use in the future.

Tynong Granite.

The Victorian Shrine of Remembrance is to be constructed of granite obtained from Tynong, Gippsland. Tynong is 43 miles south-east of Melbourne, to which it is connected by rail. Several large domes of granite form the crest of a small hill one mile north of the railway station, and the quarry is situated on the north side of one of these. There is a downward grade from quarry to railway station, which facilitates transport. This dome of granite rises about 25 feet above the ground, and outcrops over an area of about 30 feet in diameter, with no overburden whatever, and with but a quarter-inch rim of weathered iron-stained material covering the fresh granite. As is usual with granite exposed to the sun's heat, thin sheets tend to exfoliate from this outcrop and split off parallel to the domed outcropping surface. The uppermost one is about 6 inches thick. Very little quarrying has yet been done, but work is proceeding to expose the stone over a larger area in order to obtain material for the Shrine. In the weathered dome two major joints trending north-west and south-east are evident about 12-15 feet apart. These are south of the present small quarry, work in which aims at reaching them. In the preliminary workings now going on the stone is reported to split best along the "board," that is to say, horizontally. When splitting the stone vertically, north and south and east and west directions are at present selected. Lines of holes are drilled in these directions by means of a jack hammer driven by compressed air. Plugs and feathers are then inserted in the holes, and on hammering them a clean break occurs. The object of this preliminary work is to cut back to the major joint or "dry" referred to above, and down to a "board" or horizontal joint. The size of blocks to be obtained is said to be limited only by the capacity of the crane, which can lift 10 tons. The blocks so far removed average 2 ft. 6 in. square by 3 to 5 ft. in length. In the faces of stone exposed by workings in the quarry, perhaps 250 square feet, only two small "black spots" each about 1 inch in diameter were observed. One light-coloured vein about 1 inch in width, composed of coarse felspar crystals, was seen passing through the stone to the surface. Around this vein occurs a good deal of a pyritic mineral. This mineral is fortunately only observed in any amount coating joint planes, and does not extend into the body of the stone, and in a thin section very little pyritic mineral was found, so that if careful selection of pyrites-free blocks is made, little trouble from discoloration by oxidation should be experienced.

Appearance.—The rock is a very light grey granite composed of large white felspar crystals, glassy quartz and a little black mica. A small quantity of an iron sulphide mineral can be seen. The axed surface of the stone is nearly white. As described in the previous paragraph "black spots" are of very infrequent occurrence. Indeed, dark minerals are only rarely found in the main body of the rock, though patches about 12 inches in diameter occur where dark minerals are more plentiful, but are not so concentrated as to constitute a "black spot."

Working Qualities.—This granite is reported to correspond to that from Harcourt in its working qualities. The hardness of the two is nearly equal. The Tynong stone will work up to a smooth axed surface, and into rounded capitals and pediments, and will take a sharp "arris." It polishes well and easily, and looks distinctly grey when polished. The small infrequent biotite flakes being so much softer than the quartz and felspar grind away more quickly than these, leaving small pits in the polished surface.

Resistance to Crushing.—A rectangular block of this granite of approximately two cubic inches volume in a compression test crushed under a load of 25,700 lbs. per sq. in. (1652 tons per sq. ft.).

This high value is comparable only with the crushing strengths of the granites from Cape Woolamai and Orbost and the dacite from Aura of the stones described here.

Absorption Percentage.—A block of this granite with smoothly ground surfaces absorbed 0·28% of its weight of water after eleven days' immersion.

Specific Gravity and Weight per Cubic Foot.—The specific gravity was determined as 2·633, and the weight per cubic foot calculated to be 165 lbs.

Microscopic Examination.—In thin section the following minerals are seen—allotriomorphic quartz in large and small grains, of which some are interstitial, while some small grains are contained within felspar crystals and collections of other small grains are suggestive of chalcedonic quartz. The greater proportion of felspar consists of large phenocrysts of albite perthitically intergrown with orthoclase, and the remainder is plagioclase of composition between $Ab_{60}An_{40}$ and $Ab_{40}An_{60}$, which occurs in zoned phenocrysts as well as in smaller interstitial crystals. The alkali felspar is somewhat kaolinized, while the core of some of the plagioclases has altered to a sericitic aggregate. In addition to these constituents there is only a small proportion of dark-coloured minerals of which the principal ferromagnesian is brown biotite, in places altered to a green chloritic product. Zircon, apatite, fluorite, pyrite and pyrrhotite are accessory minerals. The two latter occur very sparingly, and their oxidation should do no harm to the colour of the rock when present in such small proportions. Undoubtedly these minerals occur more freely along joint planes in some parts of the quarry which should be avoided in the selection of blocks for building. The texture is holocrystalline and hypidiomorphic. The rock is a granite.

Uses.—Granite was quarried in this locality some years ago and used as pitchers in the yards at Spencer Street Station. However, as it was found to be slippery for such a purpose (a quality inherent in all granites, and not confined to this particular stone), the granite pitchers were removed. Blocks of granite from this quarry have been used as pedestals for statues in the Queen Victoria Gardens. For facing the exterior of the Shrine of Remembrance this stone is being used in smoothly dressed axed blocks. The stone with this treatment appears almost dead white, which colour is desired for the Shrine.

The Tynong granite outcrops within 45 miles of the city, is near a main railway line, and there is in sight a very large quantity of stone, so that it should prove a useful stone for building purposes in Melbourne.

Dacite.

Aura, Dandenong Ranges.

A great part of the Dandenong Ranges consists of the rock dacite, which in places has been quarried for building stone and road metal. One such quarry, a quarter of a mile east of the Aura railway station, and about 30 miles east of Melbourne, which has supplied stone for building, was visited. The place chosen for quarrying was at the outcrop of a hemi-cylindrical block about 30 feet in length. The quarry is within five yards of the narrow gauge railway line, on the high or northern side, so that drainage from the quarry should be excellent. The outcrop has a semi-circular upper surface, showing traces of exfoliation, which is stained slightly by rust and lichens. The exposed block disappears into the hill-side under an overburden of about two feet of soil containing boulders.

Two vertical joints, one due north and south and the other due east and west, are excellently developed, allowing the removal of well-shaped blocks at least 2 ft. long by 2 ft. 6 in. wide, since blocks of this area have been cut into slabs 3 inches thick and used for a veneer on a concrete building. A block now lying at the quarry measures 5 feet by 2 feet by 2 feet. No horizontal joint plane is apparent. Very little material has been removed from the quarry up to the present. The cavity worked is 4 ft. high by 10 ft. long by 2 ft. 6 in. wide.

The colour of the exposed stone is uniformly dark, only one acid vein a quarter of an inch wide being observed traversing the outcrop. The stone has been quarried by drilling holes 6 to 8 inches deep, and inserting plugs and feathers in these. No machinery has been installed, and the quarrying done up to the present has been only in the nature of scratching at the surface.

Appearance.—This rock is fine-grained, and the fractured surface is coloured dark-grey to black. Though petrologically a dacite, it falls into the trade class of "black granite." A very slight tendency to parallel arrangement of the mica is apparent in freshly-broken pieces in the field. The rock when polished is darker in colour, since there are only a few sparkling crystals of felspar to break its uniform blackness. A smoothly ground, unpolished surface of the stone has a blue tint. Quartz veins a quarter of an inch wide occur so rarely that only one out of every five finished blocks of stone contains one. The colour is unpopular in the building trade, where it is condemned as "cold." For special purposes, such as monumental work, however, the distinctive almost black colour of the polished face should be an asset.

Working Qualities.—The cutting of a small cube for a test did not present greater difficulty than is to be expected with any quartz-bearing igneous rock, though the stone is said by one man who has had experience with it, to be difficult to work. This man spoke also of the existence of " drys," whose occurrence on a dressed block makes it necessary to reject the block. A sharp knife-like " arris " was obtained on the test block. The rock takes a high polish, and its surface remains smooth and without pits after grinding. However, as the individual minerals are small and dark-coloured, there is no relief on a polished surface except for some milky quartz and a few grains of a metallic mineral. On this account probably, the polished Aura stone when used for building is relieved by blocks of unpolished stone finished by patent hammering, which gives it a light grey colour.

Resistance to Crushing.—A rectangular block approximately 2 sq. in. by 1·6 in. high crushed under a load of 26,400 lbs. per sq. in. (1672 tons per sq. ft.).

Absorption Percentage.—After immersion in distilled water for 12 days a rectangular block of this stone absorbed 0·16% of its weight of water.

Specific Gravity and Weight per Cubic Foot.—The specific gravity of this stone is 2·765, and the weight per cubic foot is 172·5 lbs.

Microscopic Examination.—This rock is remarkably free from alteration products. Felspar of composition between labradorite and andesine in zoned hypidiomorphic crystals is the most abundant mineral. A few allotriomorphic crystals of quartz occur. Of ferromagnesian minerals biotite is more prominent than pyroxene, which is represented by hypersthene. A few irregular crystals of iron sulphide are present. In a dark-coloured rock such as this one, discoloration due to the oxidation of an iron sulphide mineral need not be feared. The groundmass is granular and micro-crystalline in texture, and consists of small circular, equidimensional felspar grains and some quartz. The felspar crystals are very small, and the determination of their species is difficult, but many of them being clear and untwinned suggest orthoclase. Accessory minerals are magnetite, apatite and zircon. The rock is a biotite hypersthene dacite.

Uses.—This stone was used in a branch of the English, Scottish and Australian Bank, at the corner of Swanston and Little Bourke Streets, Melbourne. This was demolished in 1927, and upon rebuilding the dacite was not used. Polished slabs of the stone were used mainly, but around the doorway relief was given to the dark Aura stone by specimens of a grey rock with an axed finish. The locality of this rock is uncertain.

The abundant supply, the proximity to a railway track, and the uniformity of colour are all points in favour of the use of this stone, though it should be noted that Aura is on a narrow gauge railway line, and any quarried material has therefore to be transferred at Upper Fern Tree Gully to wide gauge trucks.

Porphyry.

Tallangatta.

This district contains many igneous rocks, one of which, a porphyry, has been used in Melbourne as an ornamental stone. Details of the position of the quarry with respect to the town of Tallangatta, which is 212 miles from Melbourne in a north-east direction, or of the nature of the outcrop of the rock, are not known to the writer.

Appearance.—The stone used is light pink in colour, and has large porphyritic crystals of a cream-coloured rhombic-shaped felspar and corroded crystals of quartz set in a fine-grained pink groundmass. Its attractive colour shows well when the stone is polished. Other types from the same district have been examined, which should also serve well as ornamental stones. One of these has the greenish-brown colour and fine-grained appearance familiar in the "trachyte" of Bowral, New South Wales. On a polished surface numerous rectangular porphyritic crystals of green felspar are seen. This stone polishes excellently.

Working Qualities.—A specimen of the pink rock was ground smooth and polished in the laboratory. A very even surface was obtained, and a high polish appeared on it. Other working qualities are unknown to the writer.

Resistance to Crushing.—This has not been determined.

Specific Gravity and Weight per Cubic Foot.—The specific gravity of this porphyry is 2·565, and its weight per cubic foot is 160·5 lbs.

Microscopic Examination.—Examined in thin section the rock is found to be much altered. Large quartz crystals, some idiomorphic and some corroded by the surrounding groundmass, stand out from among the rest of the minerals, which are clouded with decomposition products. Small porphyritic crystals of felspar occur, but all traces of twinning and cleavage are masked by a thick film of secondary products, such as kaolin, sericite and iron oxide, so that the species cannot be determined. Fibrous aggregates of a ferromagnesian mineral, which is a chloritic product of the original biotite, are seen. The groundmass of the rock is crystalline, and consists mainly of small felspars. The rock is a quartz felspar porphyry.

Uses.—A large rectangular block of the pink stone has been used in the Eight Hours Day Monument, erected in 1888 near Parliament House, and moved in 1923 to its present site, at the corner of Victoria and Lygon Streets. The steps and pillar of the monument are constructed of Harcourt stone, while the central block at the base of the pillar bearing the inscription comes from Tallangatta.

Its warm pink colour, the large well-shaped, cream-coloured felspar crystals, and its good polish make this stone a very handsome one.

Basalts.

Malmsbury Basalt.

The basalt of Malmsbury and district was quarried for building stone and road metal before 1861, as notes on Quarter Sheet 9 NW. published in that year record quarries for this stone. Many of the early quarries were in the neighbourhood of Green Hill, a point of eruption three and a half miles north-east of Malmsbury. Basalt quarries are working now about two miles east of Malmsbury, and half a mile west of the railway siding of Edgecumbe, on the Redesdale branch line. Several small quarries are in operation on a low rise about twenty feet in height, which at one time formed the outer bank of a meander of the Campaspe River. The river now flows to the east of its old course, and this deserted meander is now a marsh. The quarries are working into the old river bank, which by this means has been cut back about 30 feet. Pillars of stone which are useless on account of the amount of honeycomb basalt in them are left standing in the quarries. The vertical jointing system in this stone is not particularly marked in any given direction. Those working on the stone say it may be split vertically with equal ease in any direction, and vertical joints intersecting at various angles were observed in the quarry. Some of these joints are filled with a weathered layer of clay or "reef," up to one foot in thickness, between the solid basalt. These are called "clay" or "open" joints, and those where no clay appears are known as "tight joints." The stone with "tight joints" is more difficult to quarry. The vertical joint planes meet at angles which suggest that columnar jointing, with each column of a large diameter, is prevalent in this flow as in other flows of basalt. The horizontal joints or "bed" are rather uneven, and follow more or less the upper surfaces of layers of honeycomb basalt which are found through the solid stone. A characteristic section in the quarry is seen in a face of basalt about 16 feet in height. A layer of soil 1 foot in depth covers 4 feet of solid basalt, which overlies 14 inches of honeycomb basalt. Below this, 15 inches of solid stone overlies a thin "reed" or sheet of porous stone half an inch in thickness. Below this depths of solid stone of about 18 inches width are separated by layers of honeycomb basalt perhaps 6 inches in thickness or by narrower "reeds." The thicknesses of the layers of solid stone are not uniform throughout the quarry. The "honeycomb" basalt—i.e., the extremely porous stone—since it is developed in bands 6 to 14 inches thick, may mark the quickly cooled upper surfaces of individual flows, to which a great deal of gas finds its way from the body of each flow, and so forms the "honeycomb" basalt at the surface of the flow. Later, this honeycomb layer is covered by a new flow of basalt. The ease with which horizontal jointing takes place immediately above a layer of "honeycomb" basalt is probably due to this junction between flows. The "reeds," which are thin sheets of porous basalt, are never more than half an inch thick. These often occur in a horizontal plane, but also an "up and down reed" occasionally passes through solid stone from one honeycomb layer to another. It is thought that the "reeds" represent the tracks of bubbles of gas which are carried horizontally for a certain distance and then may find their way to the surface by travelling vertically or diagonally up through the flow, making an "up and down reed." Their origin is thus pictured as similar to that of the "corks" found commonly in Footscray basalt and described later. In the "reed," however, there has been no subsequent filling of the steam cavities. A type of "reed" difficult to account for is one which follows a horizontal plane for some distance, bends at right angles to a vertical plane for about 6 inches, then back to a horizontal plane again for a foot, following this the "reed" bends down again along a vertical plane, and finishes up after another bend in the same horizontal plane in which it commenced. The bubbles appear to be surmounting an obstruction of stone already solidified, perhaps a block of foreign stone being carried along by the molten basalt.

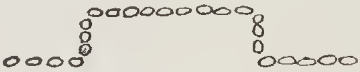

FIG. 1.—Path of "reed" in basalt, Malmsbury.

In the stone in this part of Malmsbury no "corks" are seen, but half a mile away basalt outcropping on the main road contains them. They are described and their origin is discussed in the description of the Footscray basalt. As in many other igneous rocks, "drys" occur in this basalt. They are sometimes marked by a brown iron-stained thread in the good stone as though some oxidation of iron had taken place along them.

Appearance.—The stone is fine-grained, porous and slate-grey in colour. It contains many colourless, needle-like zeolite crystals. Its uniform appearance is monotonous and unrelieved by any sparkling mineral. Two grades of stone are recognised, depending upon the porosity. First quality stone is porous, but none of the pores is larger than one-fortieth of an inch in diameter. Second quality stone is porous and contains these minute pores, but in addition some larger ones, whose diameters vary between one-eighth and one-half inch, are scattered irregularly through it.

Working Qualities.—The Malmsbury basalt is quoted by quarrymen as the standard of excellence among building stones when working qualities are considered. By means of a scavelling pick a block of stone obtained from the quarry is readily dressed to a regular shape. "Drys" in the stone, as described above, are the only flaws against which the workman has to guard when selecting blocks for dressing. The average size of the finished blocks obtained is 4 ft. long by 2 ft. by 1 ft. In a report by Lidgey published in 1894 (6), the Malmsbury basalt is described as taking "a fine polish," with which statement the writer cannot agree. A piece of first quality Malmsbury was smoothed and polished, but as was expected, the pores in the stone are so numerous that the smallest polished surface is broken by gaps where the pores intervene, and in many of them the rouge powder used for polishing lodges and is extremely difficult to remove. To overcome this disadvantage canada balsam was poured on the smooth surface of a heated block of the basalt, then baked, and allowed to cool. Grinding removed the superficial layer of balsam, and the surface was then polished. An even polish, though a poor one, resulted, since there were few pores unfilled by balsam.

Resistance to Crushing.—A two-inch cube of the stone was crushed under a load of 8,620 lbs. per sq. in. (554 tons per sq. ft.).

Absorption Percentage.—The stone absorbed 2·16% of its weight after immersion in water for five days. Absorption was complete after this period, since three weeks later no material increase in weight was found in the test block.

Specific Gravity and Weight per Cubic Foot.—The specific gravity is 2·595, and the weight per cubic foot 162 lbs.

Microscopic Examination.—The rock contains plagioclase felspar laths whose mean composition is that of labradorite, abundant squat prisms of faint green augite, corroded crystals of olivine, the larger ones completely changed to brown iddingsite, and the smaller ones colourless with a border alteration only. Magnetite is common, many crystals of it occurring in long narrow flakes. The texture is ophitic, since some of the felspar is enclosed by later crystallizing augite. On account of the extreme porosity of the rock, a thin section is rather broken. The rock is an olivine basalt.

Uses.—Malmsbury basalt was at one time used very extensively for the basecourses of large Melbourne buildings. The stone from the Green Hills quarries probably figures in many of these. Nowadays some of the stone from the quarry visited near Edgecumbe is used for basecourses, but it is generally sawn into steps and cemetery kerbing. Malmsbury basalt forms the basecourses of the following buildings in Melbourne:—English, Scottish and Australian Bank (head office), Bank of Australasia, Australian Mutual Provident, Royal Insurance, London and Lancashire Insurance, Northern Assurance, Alliance Insurance and Guardian Insurance Buildings, and many others. It is used in the gateway in the main entrance to the University. In combination with Footscray basalt it is used in the Melbourne Grammar School. Malmsbury basalt is not accepted for use on the roads, as on account of the ease with which it is worked it is regarded as too soft for this purpose. The ease with which it may be worked recommends this stone for use for building, when its dull appearance will serve as an effective contrast to a lighter-coloured stone, but it is too unattractive to be used alone in construction.

Footscray Basalt.

The quarry visited at Footscray lies north of the Footscray railway station, and is four miles west of Melbourne. Quarrying commenced here more than 25 years ago, and in that time stone has been removed over an area 150 yards square for an average depth of 20 feet. The ground here was practically horizontal originally, and the result of quarrying has been to leave a hole in the ground with the dimensions given above. Several basalt flows have occurred in this area, the later ones being superimposed on the earlier, and marked junctions occur between them. Drainage from the quarry is reported as good, since all rain water flows away through a vesicular, iron-stained basalt which forms the bottom of the main quarry. The depth below the surface at which the iron-stained band lies, varies in different parts of the quarry. At the northern end this band is 21 feet below ground level. Immediately above it lies 15 feet of solid rock, from which building stone is obtained. In the eastern part of the quarry this same vesicular band is seen 10 feet below the surface of the ground, and stone is quarried from beneath it, presumably in an earlier flow. The top of the quarry is formed by 5 feet of stone showing irregular columnar jointing. The jointing system is very irregular, even in the solid stone. In quarrying, a vertical drill-hole perhaps 26 feet deep is made with a pneumatic drill, until the iron-stained honeycomb layer is reached. A charge of powder in this hole blows out the side of the quarry, and may dislodge blocks large enough for building stone purposes. Such a block with very irregular surfaces and measuring 8 feet long by 3 feet square was seen by the writer. It was to be cut up by the use of plugs and feathers into regular-shaped kerb stones 6 or 7 feet long by 12 inches by 7 inches. Stones which spall well are cut into larger blocks suitable for basecourses. Otherwise the building stone market is not now catered for.

Horizontal layers of vesicles traverse the solid rock. They average half an inch in width, but occasionally reach two inches. They are known as " reeds," and represent the paths of bubbles of gas which have travelled through the lava along the direction of the " reed." The gas has taken a horizontal track along the level where the viscosity of the crystallising lava has prevented its further passage upward. The lava being still in motion, has drawn out the bubbles of gas into ellipses, whose long axes are arranged parallel to the direction of movement. In some " reeds " the vesicles are lined with white carbonate crystals, which penetrate into a central cavity. In such a case the quarrymen speak of a "silver reed." Elsewhere the solid stone is pierced by vertical cylindrical pipes known as "corks." These are channels whose diameters vary from one to three inches, which pass from the bottom honeycomb layer of the quarry vertically up through the stone until within 14 feet of the surface. In the uppermost 14 feet of the quarry is stone showing a great development of platy and horizontal jointing, which may represent a different flow of basalt, and through which the "corks" do not pass. The channels or "corks" show up in the normal basalt, since their margins are defined by rows of vesicles, and they are more porous than the normal stone, carrying as they do an average of 20 pores to the square inch. The pores are the shape of irregular triangles, or quadrangles, or they are circular. Some are filled with a white

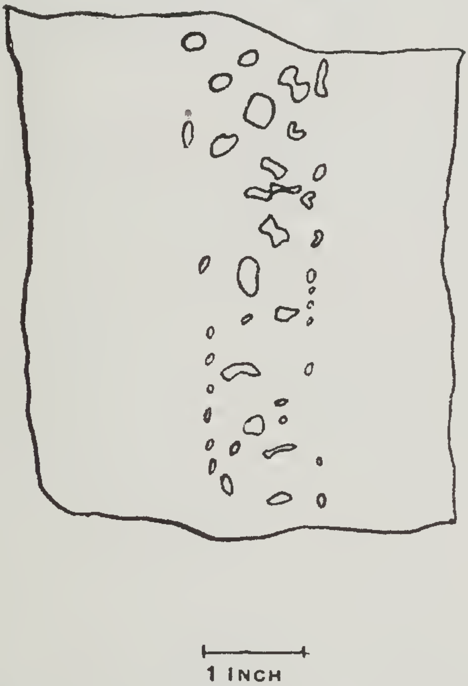

FIG. 2.—Longitudinal section through "cork." One-fourth of the larger pores are filled with carbonates. The shapes of the pores are characteristic.

carbonate mineral. The rock forming the matrix of the "cork" is finer-grained than is the normal rock. Near the bottom of the flow the "corks" are narrow, being about one inch in diameter, while towards the top they expand to about three or four inches across. At the bottom of the "cork" the white carbonate coating to the pores, which makes a "silver cork," is more commonly found than at the top of the "cork," where the vesicles remain empty, forming a "black cork." The "corks" are practically vertical, but owing to the irregularity with which a stone splits after a charge of gelignite, they appear in circular, elliptical or half-moon-shaped cross-section and look like sporadic occurrences. One "cork" was traced vertically by the writer for twelve feet

FIG. 3.—Characteristic cross-sections through "corks."

through the stone, while experienced quarrymen state that they have traced a single "cork" through the 40 feet of the stone which is worked. "Corks" are the channels by which the gases imprisoned in a lava escape to the surface. On account of the passage of gases through such a channel, the lava in its neighbourhood is rendered very porous, and is retained in the liquid state for a longer period than the surrounding lava, one result of which is the larger percentage of isotropic material seen in a thin section of a "cork," as described later under "Microscopic Examination." The "cork" expands when nearing the surface, since the overlying pressure is less.

Du Toit describes (11) in the diabasic lavas of Barkly West, South Africa, "pipe amygdales" or "bubble trains," structures very similar to "corks," which he ascribes to the "escape of steam generated in the flowing of molten rock over moist surfaces." In Victoria, since many of the basalt flows have filled old stream valleys, an analogous origin is not impossible. As described earlier, the floor of this quarry is formed by an iron-stained layer of stone which may represent the lower surface of the flow in contact with the bed of the old river.

Appearance.—This basalt is a fine-grained rock coloured dark-grey, with a slight bluish tint, which earns it the trade name of "bluestone." The whole rock is pierced by fine pores, and in addition larger circular vesicles averaging one-tenth of an inch in diameter occur about one inch apart throughout the stone. The rock is denser than the basalt from Kyneton, in which the pores and vesicles are more numerous. It contains small sparkling felspar crystals and occasionally a yellowish-green powdery mineral, probably halloysite. Blocks of otherwise solid stone contain elliptical or circular patches of varying size, which are cross-sections through the "corks" described above. In paving stones the "corks" stand up above the surface of the rocks after a certain amount of traffic over the pavements. This is seen especially on the north side of Bourke Street, between Swanston and Russell Streets. This greater resistance to wear is considered to be due to the coarser texture of the "cork," as compared with the finer-grained nature of the matrix. Another type of abnormality found in this rock is the "flint," which is a patch rich in calcium carbonate, where all pore spaces are filled with this white mineral, which has crystallized from solutions perhaps imprisoned in the rock when crystallization of the main flow prevented their escape. The "flints" are so known because it is reported that the rock in which they occur is more difficult to work than the normal basalt. They are also found in the Kyneton stone.

Working Qualities.—In spite of the irregular jointing this stone spalls remarkably well. An experienced worker easily breaks it into rectangular blocks with a hammer. However, it is not so easy to work as the more vesicular Malmsbury and Kyneton basalts. A sample was ground smooth and polished with rouge powder, which filled all the small pore spaces in the basalt, and no amount of scrubbing would remove it. The solid portions between the pores took a moderately good polish, showing a greyish-brown colour, but the general effect is far from pleasing. This result illustrates the common saying, "Basalt will not polish."

Resistance to Crushing.—A three inch cube of Footscray basalt which was crushed in 1891 fractured under a load of 10,577 lbs. per sq. in. (680 tons per sq. ft.). A two inch cube of this stone was made from material obtained in 1926 from a quarry at Footscray, and this stone proved stronger than that crushed earlier. Its crushing strength was 16,300 lbs. per sq. in. (1048 tons per sq. ft.).

Absorption Percentage.—The absorption percentage of this stone is 1·45. The absorption of water by the basalt is gradual and continuous. In five days' immersion a block measuring about one cubic inch increased in weight by 1·09%, but after thirteen days its weight had increased by 1·44%. At the end of seventeen days, when the stone had absorbed 1·45% of its weight of water, saturation was considered complete.

Chemical Analysis.—A chemical analysis of the basalt from this quarry has been made in the Victorian Mines Department Laboratory by Mr. A. G. Hall, but has not been previously published. By the courtesy of the Geological Survey permission has been given to publish it in this paper with other analyses.

Specific Gravity and Weight per Cubic Foot.—The specific gravity of the stone obtained from this quarry determined by weighing a specimen first in air and then in water is 2·570. From this value the weight per cubic foot is found to be 161 lbs. It will be noticed that the specific gravity given with the chemical analysis is 2·839. This value was obtained by weighing the powdered basalt, and since basalt is a porous rock the disagreement between the two determinations is intelligible. The first method is more useful for building stones, though it is difficult to carry out in the case of a porous rock, where some of the water is absorbed while weighing is proceeding. The result obtained is known as the "apparent specific gravity," and from it the weight per cubic foot of the stone is calculated.

Microscopic Examination.—A thin section of the normal stone of the quarry contains laths of plagioclase whose composition is between labradorite and bytownite. Many of these are set inside titaniferous augite crystals in the typical ophitic texture. Some augite shows strain polarization. Olivine is abundant, and has a brown alteration product, iddingsite, around its edges and along its cleavage planes. Occurring interstitially between some felspar laths is a colourless substance thickly studded with black globules of iron oxide and some long laths of an iron oxide mineral, magnetite or ilmenite. Since this mineral occurs in hexagonal plates, and in brown skeletal crystals, forms more characteristic of ilmenite than of magnetite, it is more likely to be the titanium-bearing iron oxide, ilmenite. Titanium is also present in the augite of this rock. The colourless matrix in which the ilmenite occurs was at first taken for volcanic glass, but Professor Skeats has pointed out that while some of this material is isotropic, much of it is not, and also the refractive index is too low for a basaltic glass, nor has it the characteristic greenish-brown colour of such a glass, and further glass in basalt is found only in a narrow tachylytic margin of a basalt flow, always less than one inch in width, while the specimen from which this section was cut comes from within a uniform mass of basalt, certainly 30 feet in thickness. In ordinary light the refractive index and colour of this material are similar to the felspar of the basalt. Where it is anisotropic its polarization colours are low in the first order, and occasionally there is a suggestion of zoning in the interstitial material. These considerations point to the interstitial material being felspar. It has been the last material to crystallize from the liquid state, and has thus filled up interstices, a role commonly taken by the quartz of quartz-bearing rocks. The iron oxide carried in this liquid has separated in the form of globules. In some cases this liquid has been supercooled below the temperature of crystallization of felspar, and has eventually solidified in the form of a felspathic glass, and hence is isotropic. In ordinary light this isotropic material is in colour and refractive index indistinguishable from that which is anisotropic, and the former also contains the iron oxide globules found in the latter. Where an augite crystal is set in this matrix the iron oxide has been drained from the latter to go to the formation of augite, and the augite crystal is surrounded by a narrow rim of clear, colourless, felspathic matrix. The rock is a porous olivine basalt.

In a thin section of a "cork" or pipe-amygdale, the materials of the normal rock are found. The interstitial felspathic glass is more abundant here, and in this case practically all of it is isotropic. In this section in addition to the globular form the iron oxide also occurs in hexagonal plates, and in brown feathery skeletal crystals (Plate XVI., Fig. 2) suggestive of incipient crystallization brought about by the mother liquor being retained in the liquid state longer than where the iron oxide is found in the globular form. When it is remembered that this material comes from the former channel for the passage of gases its less crystalline state is explicable. While passing through the "cork" the gases would tend to keep the neighbouring lava in a state of flux, with crystals of augite, olivine, felspar and iron oxide suspended in a liquor which, drained of other constituents by their crystallization and largely felspathic in composition, became supercooled below its freezing point. After the passage of most of the gases, that is to say of the fluxing agent, sudden solidification or quenching would cause the formation of felspathic glass as the matrix binding together the crystalline material. Many pores are filled with a concentrically or radially arranged calcium carbonate mineral, probably aragonite. In a thin section of a "flint" the minerals of the normal rock may be recognized. Many of the pores in the rock are filled with aragonite. Here too the felspathic matrix occurs in both isotropic and anisotropic forms, the former preponderating. Carried in it is iron oxide in both globular and skeletal-crystal forms. Hematite is noted very occasionally in the section.

Uses.—The stone from this quarry is used for screenings, for foundations in concrete roads, for gutter pitchers, paving slabs, doorsteps and staircases and, when large enough blocks are obtainable, for building stone. It is commonly used in basecourses, and can be seen in the base of the Melbourne Town Hall and of the Telephone Exchange. St. Patrick's Cathedral, Melbourne, has been constructed entirely of Footscray basalt, as have been numerous Melbourne warehouses.

The large supply, the proximity of the outcrop to Melbourne, and the comparative ease of dressing it, are to be reckoned in favour of this stone's use in Melbourne. Its dark colour considerably lessens its suitability as a building stone, and while it should make it more suitable for monumental work, the fact that it will not polish curtails its use for this purpose.

Kyneton Basalt.

Basalt in the neighbourhood of Kyneton, as well as near Malmsbury, has been quarried for building stone for many years. A quarry visited three miles south-east of Kyneton, and two miles north-west of Carlsruhe, is on the site of a very old one on a low ridge running parallel to and about one mile east of the railway line, and is 55 miles north of Melbourne.

An area 30 ft. by 40 ft. has been quarried to a depth of 25 ft. By the lease under which the stone is obtained, the quarry has to be filled as stone is taken out, so that only a small pit is left where present quarrying operations go on.

The quarry face shows a layer of overburden 2 ft. in depth, while for a further 5 ft. below the stone is broken into large boulders showing spheroidal or "onion" weathering. Below this the stone is solid though at intervals very vesicular bands about 2 in. in width occur. The stone in the upper portion of the quarry contains some sporadic vesicles or "blow-holes," which are larger than the pores of the normal vesicular basalt. The stone in the lower 15 ft. of the quarry is free from them. A series of horizontal and north-south and east-west vertical joints traverse the stone, along which weathering agents have found a track, forming a band of clay one inch in width as a result of the alteration of the basalt. Hence the joints are called "clay joints." From the "clay joints" the flaws called "drys" pass in to the good stone. The stone is liable to split along a "dry" and a block must be rejected if a "dry" appears on a dressed surface. The dry may only show after the dressing of the block is complete. The stone is found to be without "blow-holes" or "drys" about 25 feet below the surface, where flawless regular blocks 10 feet by 8 feet by 7 feet can be extracted. Vertical holes 6 inches deep are drilled 8 inches apart by means of a jumper drill along a vertical "clay joint." After the block has cracked vertically, that is, along the "cut," holes passing horizontally into the stone for 18 inches are drilled 2 feet apart on the front of the stone just above a line of honeycomb basalt if any is present. Plugs and feathers at first and, later, "lifters" are inserted in these holes, and a horizontal crack occurs which is called the "board." Along the east and west vertical joints a good face of stone is obtained. Along other vertical joints the stone is apt to break irregularly.

Appearance.—This basalt is a drab-grey vesicular one, with here and there groups of vesicles filled with an opaque white mineral which effervesces with acid, and when examined in thin section is found to be calcite. The patches which contain calcite are known as "flints," and are said to blunt tools used on the basalt. It is difficult to see why the soft mineral, calcite, in these patches should have earned them the name of "flints," though when it is remembered that elsewhere the vesicles are empty the assertion that the "flints" are harder than the normal stone is probably explained. Some vesicles are penetrated by needle-like crystals of probably a zeolite mineral, natrolite. An axed surface of this basalt is lighter grey in colour than is a rock-faced block, but both colours are monotonous and rather unattractive.

Working Qualities.—This stone is reported to be easier to work than the Footscray basalt, though it is not so easy as that from Malmsbury. In common with these other basalts it is easily broken by the hammer along plane surfaces at right angles, giving nearly smooth rectangular blocks. A great deal of quarry damp is noticed in the stone when a chip is flaked off a block just after it has been quarried.

This basalt is too vesicular to be susceptible of polishing.

Resistance to Crushing.—This porous basalt has a lower crushing strength than the denser Footscray basalt. The Kyneton stone crushed under a load of 9,220 lbs. per sq. in. (593 tons per sq. ft.).

Absorption Percentage.—Absorption percentages of both normal and "flint" types of the stone were obtained. The normal stone absorbed water slowly, and saturation was not complete until the stone had been immersed for 24 days, when it was found to have absorbed 2·92% of its weight of water. The absorption percentage of the "flint" type was 1·77, which indicates that in a "flint" nearly half the pore space of the normal basalt has been filled with secondary minerals.

Normal Footscray basalt has an absorption of 1·45%, i.e., only half that of normal Kyneton stone. The porosity of the latter makes it the easier stone to work.

Specific Gravity and Weight per Cubic Foot.—The specific gravity of the stone is 2·615, and its weight per cubic foot is 164 lbs.

Microscopic Examination.—A thin section shows fresh, unaltered labradorite felspar and augite, olivine surrounded by a rim of reddish-brown iddingsite, and some magnetite. The structure is vesicular, but many of the vesicles are coated with calcite. The mineral content and texture of this rock are typical of normal basalt.

Uses.—The main use to which the Kyneton stone is put is the construction of basecourses. Its dark colour makes an effective

Tabulated List of Tests.

Name and locality	Specific Gravity	Weight per Cubic Foot in Lbs.	Absorption Percentage	Crushing Strength Lbs. per Sq. In.	Crushing Strength Tons per Sq. Ft.
Granite, Harcourt	2·678	167·5	0·11	11,444	736
				11,333	728
				8,510	547
Granite, Wangaratta—					
Type A	2·512	157	1·45	19,600	1261
,, B	2·324	145	3·75	7,110	457
,, C	2·446	152·5	4·08	9,670	622
Granite, Cape Woolamai	2·643 (16)	165	0·18	27,100	1743
Granite, Gabo Island	2·635 (16)	165	0·39	15,260	979
				14,900	950
				17,500	1128
Granite, Orbost	2·803	175	0·15	25,400*	1633
				15,300	984
Granite, Trawool	2·666 (16)	167	0·28	not determined	
Granite, Dromana	2·605	163	0·18	17,870	1149
				16,300	1048
Granite, Colquhoun	2·616	163	0·32	14,750	946
Granite, Tynong	2·633	165	0·28	25,700	1652
Dacite, Aura	2·765	172·5	0·16	26,000	1672
Basalt, Footscray	2·570	161	1·45	10,577	680
				16,300	1048
Basalt, Kyneton	2·615	164	2·92	9,220	593
Basalt, Malmsbury	2·595	162	2·16	8,620	554

* Not actually broken, but on the point of breaking.

contrast with a lighter-coloured superstructure. The basecourses of the New Arts Block at the Melbourne University are constructed of basalt from this quarry in blocks measuring 8 ft. 9 in. by 5 ft. by 1 ft. 6 in. Waste pieces left after the shaping of larger blocks are trimmed up for gutter pitchers, etc.

The large quantity available, the ease of extraction and working, and the possibility of obtaining big blocks, are all points in favour of this stone.

Chemical Analyses.

	1	2	3	4	5
SiO_2	70·94	76·31	72·49	69·19	50·86
Al_2O_3	13·99	13·09	13·48	13·45	13·84
Fe_2O_3	0·35	0·41	1·16	2·71	4·70
FeO	3·02	1·07	2·09	2·78	6·56
MgO	0·80	0·36	0·49	1·06	8·94
CaO	2·35	0·65	1·31	2·04	8·45
Na_2O	3·94	3·00	3·38	2·89	2·59
K_2O	3·66	4·76	4·06	3·94	0·75
H_2O+	0·21	0·29	0·76	0·77	0·82
H_2O-	0·11	0·11	0·18	0·16	0·57
TiO_2	0·58	tr.	0·46	0·51	1·93
P_2O_5	tr.	—	tr.	0·18	0·23
CO_2	—	0·66	tr.	0·07	nil
MnO	—	0·11	0·13	0·14	0·20
Li_2O	—	tr.	tr.	tr.	tr.
Cl	—			tr.	tr.
NiO	—	0·01		nil	0·01
SO_3	—	nil	nil	nil	—
CoO	—	—		nil	tr.
BaO	—	—	—	—	tr.
Cr_2O_3	—	—	—	—	0·05
S	—	—	—	—	0·03
Less O = S	—	—	—	—	0·01
Total	99·95	100·43	99·99	99·89	100·52
Specific Gravity		2·643	2·635	2·666	2·839

1. Adamellite, Harcourt Quarry (Analyst, G. Ampt) (16).
2. Granite, Cape Woolamai (Analyst, A. G. Hall) (16).
3. Granite, Gabo Island (Analyst, J. Watson) (16).
4. Adamellite, Trawool Quarry (Analyst, A. G. Hall) (16).
5. Basalt, Eldridge's Quarry, Footscray (Analyst, A. G. Hall).

Summary.

In this paper are described fourteen Victorian igneous rocks used as building stones. It has been found that most of these are excellently adapted for such a purpose so far as their durability is concerned, but the long distance at which some of them occur from a market must add to the expense of using them, as for example the rocks from Gabo Island, Colquhoun, Orbost and Wangaratta.

Some are considered most suitable for ornamental purposes, as they consist of large crystals included in a fine-grained groundmass. Such are the stones from Tallangatta and Trawool. Another set, including the Aura dacite and the three basalts, being very dark and sombre in colour, needs to be combined in a building with a lighter-coloured rock to give relief.

The rock so far obtained from the quarry at Orbost is found to be too uneven in texture to be usable with success. As is pointed out in the report on that stone, probably a more even-textured stone freer from "black spots" and sedimentary inclusions will be found at depth in this quarry.

So far as working qualities are concerned, the basalts stand out as those most easily worked; next in order of ease is probably the Wangaratta stone, followed by that from Orbost. The stone from Harcourt is well known to be, for a granite, not difficult to work, while the Tynong granite is reported to approximate closely to it in ease of working.

So far as attractiveness of appearance, convenience of situation to the capital, and amount of stone available are concerned, the stone from Dromana seems to merit development; while, though its situation is somewhat remote, and the quantity perhaps limited, the working qualities and appearance of the Wangaratta stone should recommend its further use.

In the case of the granites from Wangaratta, Orbost, Dromana, Colquhoun, Tynong, the dacite from Aura, the porphyry from Tallangatta and the basalts from Footscray and Kyneton, the petrological descriptions of these rocks are here published for the first time.

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EXPLANATION OF PLATE XVI.

Fig. 1—Microphotograph—Altered Granite, Warby Ranges, Wangaratta. Ordinary light, × 26.

1. Orthoclase.
2. Hematite.
3. Hematite penetrating along cleavage crack parallel to *c* (basal pinacoid).
4. Hematite penetrating along cleavage crack parallel to *b* (clinopinacoid).

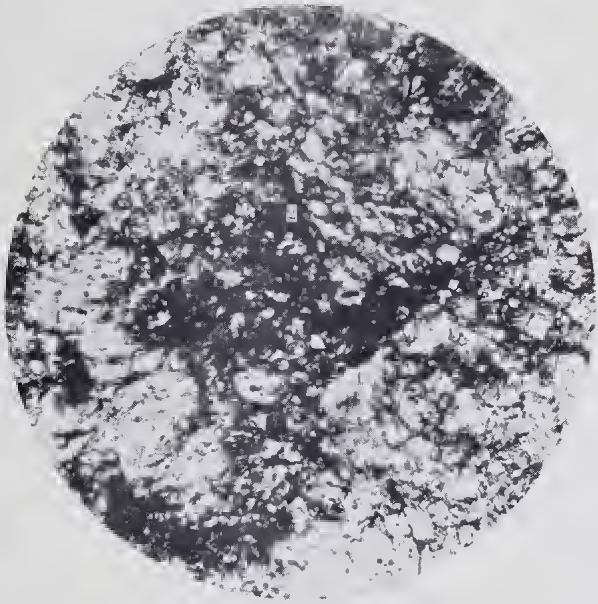

Fig. 1.

Fig. 2.